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Development of Organic Acids in Silage[1/]

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The first, second, and third cuttings of orchard grass and of alfalfa, during the 1955 season, were ensiled in 4 x 8 ft. steel silos according to treatments given in Table 1. These treatments were designed to vary the degree of air exclusion and thereby control the quality of the resulting product. The degree of severity of treatment increases in the descending columns of Table 1. The forages were chopped directly with a 3/4 inch theoretical cut. The moisture content of the orchard grass for the 1st, 2nd and 3rd cutting was 80, 73 and 77 percent respectively. For the alfalfa it was 76, 74 and 77 percent respectively. Butyric, propionic, acetic, formic, lactic and succinic acids were determined using the chromatographic technique developed by Wiseman (1). Alfalfa silage samples were taken at 0, 2, 5, 8, 12, 23 and 41 days after ensiling. Orchard grass silage samples were taken at 0, 2, 5, 8, 12, 15, 20, 27, 34, 48 and 62 days. Tables 2 and 3 give average values for butyric, acetic, and lactic acid in each silo on and after the 20th day of ensiling. The sugar values given in Tables 2 and 3 represent the reducing sugar present in the fresh green plant. Some general conclusions that may be observed from a study of Tables 1, 2 and 3 are given below.

The silages receiving the most severe treatment, namely silos 6 and 8, contained the highest percentage of butyric and acetic acids and the lowest percentage of lactic acid. Exceptions occurred in the second cutting of each crop where silos 2 and 3 contained the highest percentage of butyric and acetic acids and lowest percentage of lactic acid. However, Table 1, indicates that the treatment for silo 2 and 3 differed from that of silos 6 and 8 in only one factor. Namely, air was pumped into silos 6 and 8 for 8 hours.

In silos 1 and 7 which received the best treatment, as indicated in Table 1, butyric acid was either absent or the lowest in concentration of any of the other silos for each cutting except in the third cutting orchard grass. Acetic acid in the alfalfa silage samples was lowest in silo 1, whereas in the orchard grass samples it was next to lowest in silo 7 for the second

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and third cuttings. In the first cutting orchard grass, the acetic acid content of silos 5 and 9 was almost equal. Lactic acid in silos 1 and 7 was highest in the second cutting silages. In the first and third cutting silages, lactic acid was always high in concentration but not necessarily the highest.

The sugar content of the second cutting ensiled orchard grass and alfalfa was much lower than that of the first cutting. This fact may partially account for the greater butyric acid development shown for the second cutting silages. Although the sugar content of the orchard grass was higher than for alfalfa (with the exception of the second cutting) the alfalfa silages were usually of better quality.

Table 4 gives average acid values on and after 20 days of ensiling for all three crops of orchard grass. It shows the relationship between pH of the fresh silage and the organic acid content of fresh silage on a dry matter basis. In general acetic and butyric acids rise with increase in pH, whereas lactic decreases. Propionic acid appears to rise slowly with pH, but formic, propionic, and succinic acids are present only in small concentrations.

The data for organic acids in alfalfa silage appear to follow the same pattern as given in Table 4.

In silages of good quality, lactic acid increased quite rapidly during the first 8 to 12 days, and then leveled off and remained high. Acetic rose rapidly in the first several days to 1 to 3% and then showed a gradual rise. In this experiment acetic acid was generally 1 to 2% higher in the alfalfa silage than in orchard grass. Butyric acid was absent or, if present, in quantities less than one percent.

In mediocre or poor silages, lactic acid rose quite rapidly the first 5 to 8 days and then decreased often to less than 1% in 10 to 20 days. Butyric acids usually appeardd after the 5th to 8th day and sometimes increased to 4 to 6%. Acetic acid, although fluctuating, often paralleled the behavior of butyric acid in the 20 to 40 day period after ensiling.

Preliminary bacteriological investigation showed an increase in sporeforming anaerobes that paralleled the increase of butyric acid and pH of the silages. Two groups of sporeformers were isolated from the silages. One was an active lactate fermenter and the other one was proteolytic.

Treatments designed to increase the time before air was excluded from the forage, produced silages of markedly inferior quality as compared to those produced by a method providing rapid air exclusion. The acid development of the good and bad silages is described in the two preceding paragraphs. It is possible that continued plant respiration and improper utilization of fermentable carbohydrates under aerobic conditions have been factors contributing to the unfavorable fermentation. The naturally occurring carbohydrates, in all except the second cutting orchard grass forage, apparently have been sufficient for a favorable fermentation when protected by rapid air exclusion.

Table 3 - Available Sugar and Organic Acids of Alfalfa Silage - 1955

Cutting	Silo No.	Average % Acid D. M. - 20 to 41 days after ensiling			% Sugar D. M. at 0 days
		Butyric	Acetic	Lactic	
1st	1	0	2.84	11.74	6.82
	4	0	3.94	12.60	6.07
	10	0	3.43	10.92	5.33
	3	0	3.82	10.60	6.09
	8	0.07	4.68	6.81	5.33
2nd	1	0.02	2.83	7.05	4.83
	4	0.12	3.93	5.89	4.49
	10	0.15	3.76	6.26	4.29
	3	3.77	4.78	2.10	3.60
	8	2.31	3.20	2.50	3.57
3rd	1	0	2.04	8.23	3.43
	4	0	3.37	6.22	4.89
	10	0.03	4.77	3.91	4.49
	3	0.65	4.00	3.22	4.49
	8	1.95	4.89	2.06	4.11

Table 4 - Relationship of pH to Organic Acid Content of Orchard Grass Silage 1955, Small Silos

pH range	Formic	Acetic	Propionic	Butyric	Lactic	Succinic
3.8-4.0	.08	1.62	.08	.22	8.86	.45
4.0-4.2	.09	1.69	.10	.32	8.67	.56
4.2-4.4	.09	2.11	.19	.94	7.49	.62
4.4-4.6	.13	1.39	.10	1.22	3.81	.69
4.6-4.8	.07	1.29	.16	1.55	2.49	.71
4.8-5.0	.13	1.10	.23	2.70	1.12	.71
5.0-5.2	.15	2.00	.42	3.28	0.71	.56
5.2-5.4	.17	2.27	.55	3.28	1.14	.67
5.4-5.6	.26	2.66	.54	3.36	.50	.22
5.6-5.8	.25	3.24	.82	4.19	.38	.40
5.8-6.0	.09	4.03	.56	6.01	.49	.63

Table 1 - 1955 - Silage Treatments

Orchard Grass Silo No.	Alfalfa Silo No.	Treatment
7	1	Tramped, sugar 20 lb/ton, 500 #wt. added, sealed immediately.
5	4	Tramped, 500 #wt. added, sealed immediately.
9	10	500 #wt. added, 1st cutting sealed after 48 hrs. -2nd and 3rd cutting sealed after 1 week.
2	3	Not tramped, no seal, so weight.
6	8	Not tramped, no seal, no weight. Air pumped in for 8 hours.

Table 2 - Available Sugar and Organic Acids of Orchard Grass Silage - 1955

Cutting	Silo No.	Average % Acid D. M. - 20 to 62 days after ensiling			% Sugar D. M. at 0. days
		Butyric	Acetic	Lactic	
1st	7	0	2.43	9.71	9.47
	5	0	2.23	10.01	5.32
	9	0	2.22	9.73	9.41
	2	0.57	2.69	9.45	8.42
	6	5.48	4.28	0.90	8.42
2nd	7	1.24	1.37	4.05	3.95
	5	2.49	1.10	1.51	4.33
	9	2.98	1.52	0.72	3.43
	2	3.75	2.97	0.46	2.98
	6	2.65	2.14	1.15	2.64
3rd	7	0.79	0.90	7.78	6.59
	5	0.93	0.88	6.87	7.54
	9	0.04	1.44	8.31	6.37
	2	0.10	1.26	8.04	6.37
	6	3.44	2.27	1.14	7.40